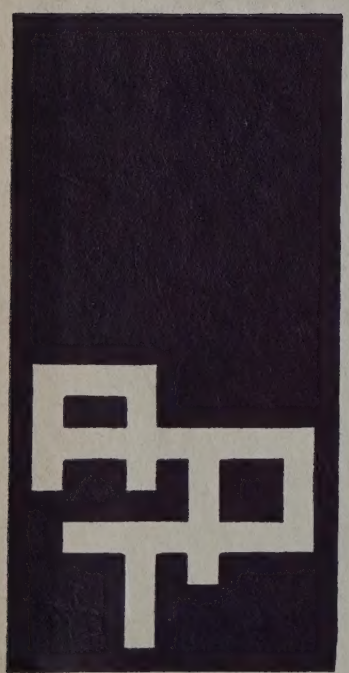

A.P.T Electronic
Industries Ltd

Chertsey Road
Byfleet
Surrey
England

telephone
Byfleet 41131-4

technical handbook

POWER UNIT

MODEL TCU 250

REGULATED POWER UNIT

TCU 250

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Chertsey Road - Byfleet - Surrey - England.

Telegrams:- APTRAN BYFLEET Telephone:- BYFLEET 41131.

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MODEL TCU 250

SPECIFICATION

Mains input	200-250V a.c. 45-65 Hz, single phase
Output current	2A maximum
Output voltage	0-50V d.c. in five switched steps with continuous control over a 10V range at each step.
Overload protection system	Delayed electronic trip system reduces output current and voltage to zero under short-circuit conditions; constant current characteristics during delay period: push button reset.
Ripple and noise	Not greater than 1 mV peak-to-peak
Output resistance (d.c.)	Not greater than 0.01 ohm. (Typically 0.004 ohm)
Output impedance	Less than 0.3 ohm up to a frequency of 1 MHz
Stabilization ratio (for ± 10% change in input voltage)	Varies with output voltage (Typically 3000:1) For output voltage in the range 5-50V- Not less than 1500:1 For output voltages in the range 0-5V- Falls towards 1000:1
Temperature coefficient of output voltage	Less than 0.02% (200 p.p.m.) per ° C.
Temperature range	Up to 40°C under continuous full load.
Dimensions	Height - 25.4 cm. (10 in.) Width - 13.9 cm. (5.1/2 in.) Depth - 20.3 cm. (8 in.)
Weight	8.6 kgs (19 lbs. 2 ozs.) including mains cable.

INTRODUCTION

The regulated power supply unit type TCU-250 is a fully stabilized unit, from which an output of up to 50V can be obtained at a maximum load current of 2A. The output voltage is fully variable over the range 0-50V and complete overload protection is provided.

The unit is housed in a dark green steel case with a light grey front panel on which are mounted a dual-scale meter, output terminals, and all controls. The mains cable entry is via a 3-pin plug situated at the rear of the unit.

OPERATING NOTES

Mains connection

The unit is supplied with a 3-core mains lead which is colour-coded in accordance with BS: 6500 1969. A suitable 3-pin mains plug should be connected to the free end as follows:

Core	Pin
BROWN	LIVE
BLUE	NEUTRAL
GREEN/YELLOW	EARTH

Mains transformer taps

The unit leaves the factory adjusted for operation on 240V mains supplies. If the mains supply is of some other nominal voltage, ensure that the selected taps on the primary of the mains transformer correspond to the mains voltage to be used. Access to the terminal pins to which the taps are wired is obtained by removing the four screws at the rear of the unit and withdrawing the unit from its case. The primary taps will be seen on the right of the transformer tag board, as viewed from the rear of the unit.

Note: It is quite probable that although the nominal mains voltage may be, for example, 240V, during the greater part of the working day it may be as low as 230V. Consequently the mains tap should be selected with this in mind.

Indicator lamp

The indicator lamp is a sub-miniature LES lamp which illuminates the red window in the maker's name plate situated below the meter. The lamp indicates that the mains supply is on. For replacement instructions see page 7.

Output terminals

The load should be connected between the positive and negative output terminals, with the earth terminal linked to either output terminal as required. If a 'floating' supply is required the earth terminal remains unconnected.

WARNING When used as a floating supply, neither output terminal should be more than 500V d.c. above or below earth potential.

Output voltage

The output voltage of the unit is set by the two front panel controls, the OUTPUT VOLTAGE switch and the 0-10V control. The upper control is a potentiometer which covers a range of 10 volts and the lower control is a 5-position switch which changes the output voltage in 10V steps. Because there is a slight overlap on each range, it is possible to obtain the same voltage, either at the upper end of one range or, at the lower end of the next highest range.

Meter and meter-switch

The meter can monitor either the output voltage or the current supplied to the load, depending on the setting of the meter switch. The upper scale of the meter is calibrated 0-50V and the lower scale 0-2.0 amps.

Trip current control

The TRIP CURRENT control which is mounted on the front panel of the unit, is used to set the load current at which the overload protection circuit trips and shuts down the output voltage and current.

It will be seen that the maximum setting of this control is 400 mA above the maximum rated current for the unit. This is to enable the unit to supply its maximum rated current without the overload trip being set so critically that the unit might trip out on a minor and transient overload. It is stressed, however, that this should not be taken to indicate that the unit is intended to operate at a load current in excess of 2.0 amps.

Trip reset push-button

Depression of the TRIP RESET push-button will restore the normal output after the overload protection system has tripped, provided the overload condition has been removed. Repeated attempts to reset while the overload is still present will not restore the output nor harm the unit.

Series connection

The outputs of two or more units of the same type may be connected in series when a higher voltage than can be obtained from one unit is desired.

Parallel connection

No provision is made for parallel connection and under no circumstances should the output of one unit be paralleled with the output of another.

Remote sensing

In a situation where the voltage drop along the cables connecting the unit to the load is not negligible it is desirable to sense the voltage across the load rather than the terminal voltage of the power unit, for the purposes of control. To facilitate this, the input terminals of the control amplifier are brought out to the front panel, enabling separate 'sensing' leads to be run from the power unit to the load. The amplifier terminals are designated + and - and should be connected to the output leads of like polarity at the load itself. For a fuller explanation and details of connecting leads see Appendix A, page 8.

Operation with pulse or switched loads

The unit is suitable for applications in which the load current is subject to rapid variations. For a full description of operation under such conditions see Appendix B, page 10.

BRIEF CIRCUIT DESCRIPTION

General

The unit is constructed in modular form and consists of four sub-assemblies designated X1 to X4. Each sub-assembly has its own circuit references starting at unity for each group of components. The circuit diagram shows the interconnection of the sub-assemblies and the circuit references for those components not located on any particular sub-assembly.

The basic circuit (Fig. 1)

The mains supply is routed into the unit via a 3-pin plug PL1 and the circuit to the power transformer is completed by a single pole, single throw switch S1. Fuse FS1 protects the transformer against a short-circuit in the transformer rectifier assembly (X1). Two sub-rectifier circuits, fed from separate secondary windings of the power transformer, provide power for the Control Card amplifier (X2) and the sub-drive transistor (TR8) respectively.

Power for the output of the unit is derived from a bridge rectifier network fed from the main secondary winding of the power transformer. This winding has 5 tapping points, any one of which can be selected by the S3a wafer of OUTPUT VOLTAGE control. Position '0' of the control corresponds to a secondary voltage sufficient to provide a range of output voltage from 0 to 10 volts, as determined by the adjustment of the '0-10V' control (RV2). The remaining 4 positions increase the secondary voltage in increments corresponding to 10 volts steps in output voltage up to 40 volts. The full output of 50 volts is obtained by setting the OUTPUT VOLTAGE control to 40V and the '0-10V' control to its maximum resistance.

The series stabiliser element comprises the Heat Sink assembly (X3) upon which is mounted two series stabiliser transistors connected in parallel, together with their associated components. The output voltage of the unit is maintained constant over the operational current range by varying the effective series impedance of the stabiliser transistors according to the load placed on the power unit. The control potential applied to the bases of these transistors is derived from a continuous comparison of the output voltage of the unit with a closely controlled reference potential in the Control Card circuit. The S3b wafer of the OUTPUT VOLTAGE control together with the 0-10V control (RV2) adjust the datum point of the voltage comparator amplifier to compensate for different selected output voltages.

The built-in meter M1, which has an f.s.d. of 1 mA, measures the output voltage or current, depending on the setting of the meter switch S4. When S4 is set to VOLTS, the meter is connected in series with a pre-set potentiometer and a series resistor across the output of the power unit. When S4 is set to AMPS, the meter indicates the load current, with resistor R7 in series with the positive output line forming the shunt resistor.

The overload protection system is incorporated in the Control Card circuitry. In the event of an overload or short-circuit being applied to the unit, the normal voltage control circuits are overridden and the output voltage and current are reduced to zero. A short delay of approximately half a second is introduced before the circuit trips. During the delay period the power unit has a constant current characteristic to enable large capacitive loads to be supplied without risk of the circuit tripping on initial switch-on. Once tripped, the protection circuit will maintain the power unit shut down until the RESET push-button is depressed. Then, providing the overload conditions are no longer present, the output voltage and current will return to normal. The setting of the front panel TRIP CURRENT control, in conjunction with a preset potentiometer on the control card determines the current at which the overload circuit trips.

REPAIR AND MAINTENANCE NOTES

The components and circuit design of this power unit are such that, providing the unit is not subject to misuse or damage, years of trouble-free life may be expected with no maintenance or repair other than the changing of a fuse or indicator lamp.

Fuse replacement

Disconnect the unit from the mains. Access to the fuse is gained by unscrewing the four screws at the rear of the unit and withdrawing it from its case. The fuse (5 amp cartridge type) is located at the left-hand rear of the unit.

Before replacing a ruptured fuse, always inspect the unit for any obvious signs of failure likely to cause the fuse to blow.

Indicator lamp replacement

Disconnect the unit from the mains. Prise up both ends of the maker's nameplate and pull it clear of the front panel. Carefully turn the lamp holder through 90° to facilitate removal of the lamp. When refitting, ensure that the leads to the lamp holder are not trapped between the nameplate and the front panel, also that the lamp and lamp holder pass easily through the slot in the front panel. The name plate can now be pushed home.

APPENDIX A

REMOTE SENSING

As outlined on page 5, in a situation where the voltage drop along the cables connecting the unit to the load is not negligible, advantage should be taken of the Remote Sensing facility.

The need for this facility is much less in a general-purpose power supply unit than in a unit for a fixed installation, since it is usually possible to keep the arrangement and lengths of the connecting leads such that their voltage drop is insignificant. For this reason, and because it would be a nuisance always to have to make separate connections to the Ampr. sockets, the sockets are linked to the output terminals by low-value resistors inside the unit. For most normal applications it is possible to use the unit by connecting the load to the output terminals and ignoring the Ampr. sockets, the resulting loss of performance being very minor.

Within the power unit itself, the wiring layout is arranged to keep the loop self-inductances to a minimum and the circuit design is such that the output impedance is low and the transient response is very good. The very high performance which the unit can provide to a load connected directly to the output terminals can be degraded appreciably by even quite short connecting leads if these are badly disposed.

In cases where the output impedance of the power supply is to be kept to the minimum, it may be necessary to use the remote sensing method. If it is only the d.c. resistance which is important the actual layout of the connecting leads will be unimportant but if considerations of a.c. impedance and output ripple are important it will be necessary to dispose the connecting leads with some care.

If the connecting leads are not positioned carefully (the leads from the Ampr. outputs not run tightly and close to the leads from the output terminals) the following disadvantages may result:

(a) The large loop formed by the high current conductors to the load inserts extra inductance in series with the load. If the load current is subject to rapid variations this can make the transient response of the power supply unit appear to be very poor. The importance of this factor is more readily appreciated when it is realized that a change of load current at the rate of one Ampere per microsecond, which is not uncommon, produces an inductive e.m.f. of one volt in a loop circuit with a self inductance of only one microhenry. The use of the remote sensing connections under such conditions can result in the voltage comparator amplifier being severely overloaded transiently and the overall transient response of the system thus becoming even worse.

(b) The large loop formed by the remote sensing leads can pick up considerable electro-magnetic interference from surrounding stray fields, producing abnormally high output ripple or noise.

That the performance of the unit depends upon the way in which the connections are made to the load, is not a defect in the design of the unit. The problem is simply that the power supply unit, the load and the connections between them are all parts of a high-gain feedback loop and, as is well known, there are strict limitations as to how far it is possible to correct for deficiencies by the use of feedback.

As a general guide to the use of the remote sensing facility, the following are recommended limitations:

(a) The total volt drop at maximum load current in the heavy current conductors should not exceed 0.2 volt for the complete loop circuit.

(b) The resistance of each of the two remote sensing connections to the amplifier sockets should be kept as low as possible, preferably not greater than 0.1 ohm and in extreme cases even lower.

APPENDIX B

OPERATION WITH PULSED OR SWITCHED LOADS

As mentioned on page 5, the unit is suitable for use in such applications but the following points are worthy of mention.

It is a characteristic of transistors in general that they are charge operated devices, so that it is necessary to inject or subtract a certain amount of excess charge in the base circuit in order to bring about a change in the collector current. This is the cause of the finite 'turn-on', 'storage' and 'turn-off' times quoted for transistors when operating in a switching mode. This factor is particularly relevant to transistorized power supply units when operating under switched or pulsed loading conditions.

The effect is most significant in the power transistor in the series regulator circuit and gives rise to the following effects:

(a) If the power unit is initially delivering only a small output current and there is a sudden demand for a larger current, even an instantaneous change in base current or potential cannot force the power transistors to pass the increased collector current instantaneously. During the short 'turn-on' period the extra load current has to be derived from the capacitor across the output terminals and there is a consequent transient fall of output voltage.

(b) If the power unit is initially delivering a large output current and there is a sudden reduction in the load current, the series regulator transistors cannot instantaneously be forced to deliver a reduced collector current. During the short 'turn-off' period an excess current is delivered to the output terminals and stored in the shunt capacitors, so that there is a transient rise of output voltage.

Effects of the type discussed in (a) and (b) above depend upon the magnitude of the change in load current rather than the actual mean load current level, particularly with regard to para. (b). For this reason the best possible transient response is obtained when the variable part of the load current is only a small proportion of the total mean load current. If work is being done on a circuit which draws an impulsive load current and freedom from voltage transients is important, it is advisable to put an additional fixed load resistor across the output terminals of the power unit such that the peak current drawn from the unit approaches the full load rating of the unit.

When operating into a load circuit which draws current in short duration pulses it is important to remember that the overload protection system may come into action on excessive current even though the mean current shown on the meter is below the maximum rating of the unit. With loads of this nature it is

possible for the load on the power unit to run into the constant current delay period of overload protection, without actually 'tripping out'. This will cause no damage but will make the power unit appear to have poor regulation and transient response.

If the power unit appears to have bad regulation and to exhibit serious voltage transients when operating into an impulsive type of load circuit it is advisable to check the magnitude of the peak current being drawn from the unit and to make sure that the power unit is not, in fact, being overloaded.

COMPONENTS LISTS

MAIN ASSEMBLY TCU-250

Circuit Ref.	Value	Tol. ±%	Rating	Description	A.P.T. Part No.
R1	270 ohm	5	1/2W	Resistor Metal Oxide	23125-271
R2	8.2 kilohm	5	1/2W	Resistor Metal Oxide	23125-822
R3	2 kilohm	1	3/4W	Resistor Wirewound	25121-202
R4	2 kilohm	1	3/4W	Resistor Wirewound Type SFM	25121-202
R5	2 kilohm	1	3/4W	Resistor Wirewound Type SFM	25121-202
R6	2 kilohm	1	3/4W	Resistor Wirewound Type SFM	25121-202
R7	0.25 ohm	1	1 W	Resistor Wirewound Type ESF	25411-258
R8	1 ohm	5	2 W	Resistor Wirewound Type SF	25325-107
R9	1 ohm	5	2 W	Resistor Wirewound Type SF	25325-107
RV1	1 kilohm	10	2 W	Resistor Variable Wirewound	27004-102
RV2	2.5 kilohm	10	2 W	Resistor Variable Wirewound	27004-102
C1	10 µF	-10 +50	64 V	Capacitor Elect.	11022-106
C2	3600 µF	-20 +50	85 V	(2x1800µF) Capacitor Elect.	11003-188
C3	1800 µF	-20 +50	85 V	Capacitor Elect.	11003-188
S1	-	-	-	Switch Rocker 2 Pole ON/OFF	41902-016
S2	-	-	-	Switch Push Button C/O	43101-407
S3	-	-	-	Switch Rotary 2P. 5 POS	440-17590
S4	-	-	-	Switch Rotary 2P. 2 POS	440-18557
M1	-	-	0-50V 0-2A	Meter 4" Rectangular	380-34683/3
PL1	-	-	-	Plug 3 PIN	51104-103
LP1	6.5V	-	1 W	Lamp. Sub. Min. L.E.S. (tubular)	65101-008
D1	1N4720	-	-	Rectifier Silicon	71251-001

TRANSFORMER RECTIFIER ASSEMBLY -X1

Circuit Ref.	Value	Tol. ±%	Rating	Description	A.P.T. Part No.
T1	-	-	-	Transformer	340-30450
FS1	5 A	-	-	Fuse Cartridge	62310-502
R1	4.7 ohm	5	3/4W	Resistor Wirewound Type SFM	25125-477
R2	330 ohm	5	1/2W	Resistor Metal Oxide	23125-331
R3	15 ohm	10	1/2W	Resistor Carbon	21121-150
R4	8.2 kilohm	5	1/2W	Resistor Metal Oxide	23125-822
C1	500 µF	+50 -20	30 V	Capacitor Electrolytic	11001-507
C2	1000µF	+50 -20	15 V	Capacitor Electrolytic	11002-108
C3	0.047µF	10	160V	Capacitor Polyester	13111-473
D1	BYX36-150	-	-	Rectifier Silicon	71211-001
D2	BYX36-150	-	-	Rectifier Silicon	71211-001
D3	BYX36-150	-	-	Rectifier Silicon	71211-001
D4	BYX36-150	-	-	Rectifier Silicon	71211-001
D5	1N4720	-	-	Rectifier Silicon	71251-001
D6	1N4720	-	-	Rectifier Silicon	71251-001
D7	1N4720	-	-	Rectifier Silicon	71251-001
D8	1N4720	-	-	Rectifier Silicon	71251-001

CONTROL CARD (TYPE A) -X2

Circuit Ref.	Value	Tol. ±%	Rating	Description	A.P.T. Part No.
R1	4.7 kilohm	5	1/2W	Resistor Metal Oxide	23125-472
R2	1 kilohm	5	1/2W	Resistor Metal Oxide	23125-102
R3	180 ohm	5	1/2W	Resistor Metal Oxide	23125-181
R4	27 ohm	5	1/2W	Resistor Metal Oxide	23125-270
R5	2.2 kilohm	5	1/2W	Resistor Metal Oxide	23125-222
R6	1 kilohm	2	1/2W	Resistor Metal Oxide	23122-102
R7	2.7 kilohm	5	1/2W	Resistor Metal Oxide	23125-272
R8	4.7 kilohm	5	1/2W	Resistor Metal Oxide	23125-472
R9	3.3 kilohm	5	1/2W	Resistor Metal Oxide	23125-332

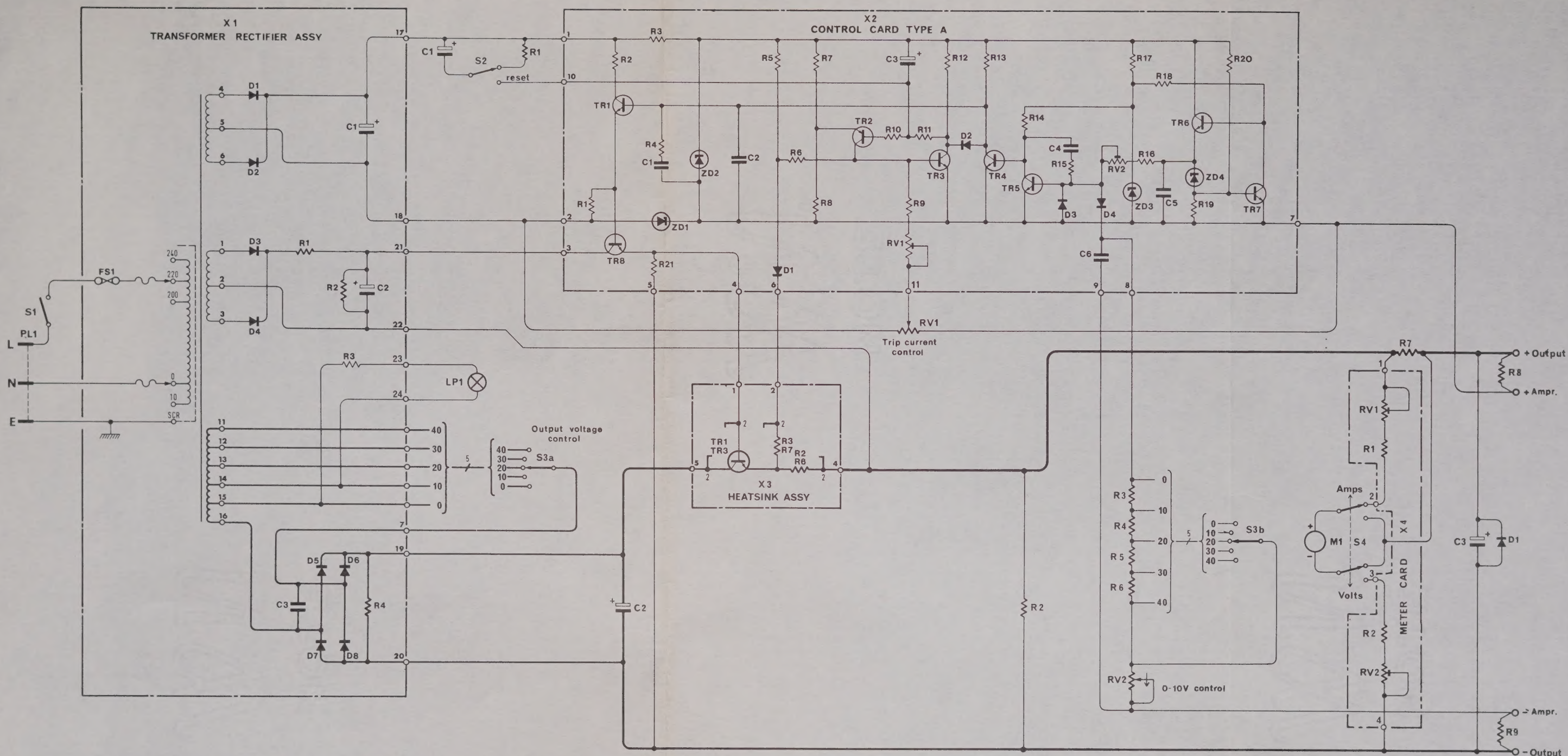
Circuit Ref.	Value	Tol. ±%	Rating	Description	A.P.T. Part No.
R10	1 kilohm	5	1/2W	Resistor Metal Oxide	23125-102
R11	22 kilohm	5	1/2W	Resistor Metal Oxide	23125-223
R12	4.7 kilohm	5	1/2W	Resistor Metal Oxide	23125-472
R13	3.3 kilohm	5	1/2W	Resistor Metal Oxide	23125-332
R14	5.6 kilohm	5	1/2W	Resistor Metal Oxide	23125-562
R15	100 ohm	5	1/2W	Resistor Metal Oxide	23125-101
R16	1050ohm	2	3/4W	Resistor Wirewound	29622-001
R17	270 ohm	5	1/2W	Resistor Metal Oxide	23125-271
R18	2.2 kilohm	5	1/2W	Resistor Metal Oxide	23125-222
R19	110 ohm	5	1/2W	Resistor Metal Oxide	23125-111
R20	47 kilohm	5	1/2W	Resistor Metal Oxide	23125-473
R21	8.2 kilohm	5	1/2W	Resistor Metal Oxide	23125-822
R22-23				Not fitted	
RA-RE				Not fitted	
RV1	5 kilohm	10	1/2W	Resistor W/W Preset	27101-502
RV2	250 ohm	10	1/2W	Resistor W/W Preset	27101-251
RV3				Not fitted	
C1	0.047µF	10	160V	Capacitor Polyester	13111-473
C2	4700pF	20	400V	Capacitor Polyester	13112-472
C3	12.5µF	-10 +50	25 V	Capacitor Electrolytic	11018-126
C4	0.1 µF	10	160V	Capacitor Polyester	13111-104
C5	0.1 µF	10	160V	Capacitor Polyester	13111-104
C6	0.47µF	10	160V	Capacitor Polyester	13111-474
TR1	BC107	-	-	Transistor	74221-001
TR2	BCY72	-	-	Transistor	74211-002
TR3	BC108	-	-	Transistor	74221-002
TR4	BC108	-	-	Transistor	74221-002
TR5	BC108	-	-	Transistor	74221-002
TR6	BC108	-	-	Transistor	74221-002
TR7	BC108	-	-	Transistor	74221-002
TR8	BFY52	-	-	Transistor	74222-002
D1	SG949A	-	-	Diode, Silicon	71215-001
D2	SG949A	-	-	Diode, Silicon	71215-001
D3	BYX36-150	-	-	Diode, Silicon	71211-001
D4	BYX36-150	-	-	Diode, Silicon	71211-001
D5-7				Not fitted	
ZD1	BZY88C5V6 (5.6 V)	-	-	Diode, Zener	72225-567
ZD2	VR9F (9.0 V)	-	-	Diode, Zener	72235-907
ZD3	BZY88C7V5 (7.5 V)	-	-	Diode, Zener	72225-757
ZD4	BZY88C5V6 (5.6 V)	-	-	Diode, Zener	72225-567

HEATSINK ASSEMBLY -X3

Circuit Ref.	Value	Tol. ±%	Rating	Description	A.P.T. Part No
R1				Not fitted	
R2	0.5 ohm	2	1 W	Resistor A.P.T. W.W. Bifilar	29312-508
R3	10 ohm	5	1/2W	Resistor Metal Oxide	23125-100
R4-5				Not fitted	
R6	0.5 ohm	2	1 W	Resistor A.P.T. W.W. Bifilar	29312-508
R7	10 ohm	5	1/2W	Resistor Metal Oxide	23125-100
TR1	2N3055	-	-	Transistor	74225-001
TR2				Not fitted	
TR3	2N3055	-	-	Transistor	74225-001

METER CARD -X4

Circuit Ref.	Value	Tol. ±%	Rating	Description	A.P.T. Part No
R1	330 ohm	5	1/2W	Resistor Metal Oxide	23125-331
R2	47 kilohm	5	1/2W	Resistor Metal Oxide	23125-473
RV1	150 ohm	10	1/2W	Resistor Variable Wirewound	27101-151
RV2	5 kilohm	10	1/2W	Resistor Variable Wirewound	27101-502



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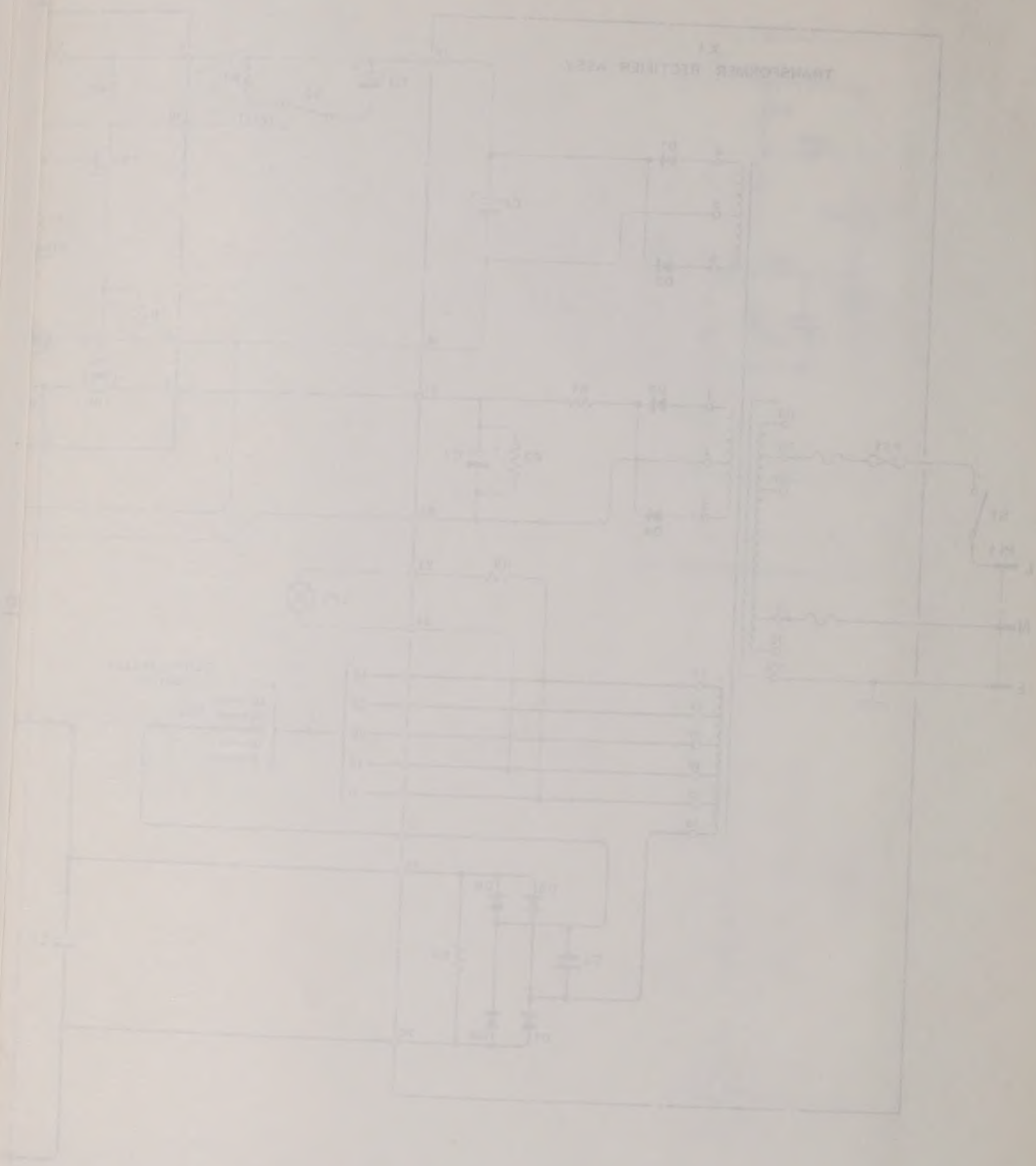
MODEL TCU 250

FIG. 1.



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